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Indigenous

Soil and Water Management

Practices Prevail in the Tribal Farmlands of Balaghat District in Madhya Pradesh

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Institute Technology Management Unit (ITMU)

ICAR - Indian Institute of Soil Science

Nabibagh, Berasia Road, Bhopal-462038 (M.P.)

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FOREWORD

Indigenous knowledge systems of traditional farming communities are valuable assets as those are capable of explaining many issues associated with present day agriculture. Indigenous agriculture technologies are mostly developed out of the prolonged farming experiences and thought processes of primitive cultivators as practical solutions to their problems. Hence, proper documentation of different agricultural technologies inherited from indigenous farmers through oral tradition is of utmost importance. The technical bulletin entitled "Indigenous soil and water management practices prevail in the tribal farmlands of Balaghat district in Madhya Pradesh" contains first hand information on actual land resource management techniques practiced by the tribal farmers living in dense forests of the state. Efforts taken by the authors for collecting the required information as well as the tribal farming communities for sharing the minute details of different technologies they practice in farmlands are really appreciable. I congratulate the authors for bringing out this publication.

March, 2021
Bhopal

(ASHOK K. PATRA)
Director
ICAR-Indian Institute of Soil Science

PREFACE

ICAR-Indian Institute of Soil Science, Bhopal has been working for the last 32 years towards the development of Soil Health Management (SHM) technologies ideal for cultivating different crops sustainably in various soils of India. Along with the basic and strategic research activities, the institute is also engaged with participatory research activities for developing localised SHM technologies. For that, knowledge about crops and cropping systems, soil and water management practices, and other farm management activities of selected localities are necessary. This bulletin "Indigenous soil and water management practices prevailing in the tribal farmlands of Balaghat district in Madhya Pradesh" is the result of a participatory technology development programme of the institute for the tribal farmlands of Balaghat district of Madhya Pradesh. We hope that the Indigenous Agricultural Technologies documented in this bulletin would be useful for the researchers, technology developers and farmers.

March, 2021 — Authors

Bhopal

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BACKGROUND

Tribal population is an integral part of forest ecosystem constituting nearly 8.6 percent of Indian population (104545716 as per 2011 census data). Being the state that ranked top in terms of Recorded Forest Area (RFA) in India with 94,689 sq km forest cover Madhya Pradesh[1] occupies the largest tribal population (15316784 that accounts for nearly 14.6 percent of total Indian tribal population and 21.1 percent of total Madhya Pradesh population). Though there are 46 recognized tribes in Madhya Pradesh about 90 percent of tribal population belong to six tribal communities *viz*., Bhil, Gond, Kol, Saharia, Baiga and Kurku. These tribal groups are mainly distributed in 21 districts located in the southern, central, and eastern parts of the state (Figure 1).

The 2011 census data described 'Bhil' and Gond as the two most dominant tribal communities found in Madhya Pradesh and they make up nearly 73.3 percent of the total tribal population of the state. Bhil tribes mostly confined to districts under the Indore division of the state viz., Jhabua, Dhar, Barwani, Khargone, and Alirajpur. Gond tribes mostly found in the Chhindwara, Mandla and Balaghat, districts of Jabalpur division, Sagar and Damoh districts of Sagar division, and Shahdol districts of Shahdol division. The third major tribal community 'Kol' mainly occupy the Rewa, Sidhi, and Satna districts of Rewa division; and Saharia tribal community live in the northern districts of the state like Shivpuri, Guna, Morena, and Rajgarh. The real forest dwellers are 'Baiga tribe' who mostly live in dense forest and hilly tracts. They are spread in the Dindori district of Shahdol division and Mandla, Balaghat, and Seoni districts of Jabalpur division.

Agriculture is the prime livelihood activity of tribal communities and the form of agriculture they practice is 'subsistence farming' where they grow crops mainly to feed the family. In earlier periods mostly they lived a nomadic or semi-nomadic life with hunting and gathering as well as shifting cultivation. But, when the growing population restrained them in accessing adequate livelihood resources through wandering within the forest ecosystem most of the tribal population shifted slowly to settled agriculture. They also engaged with collection and selling of minor forest products.

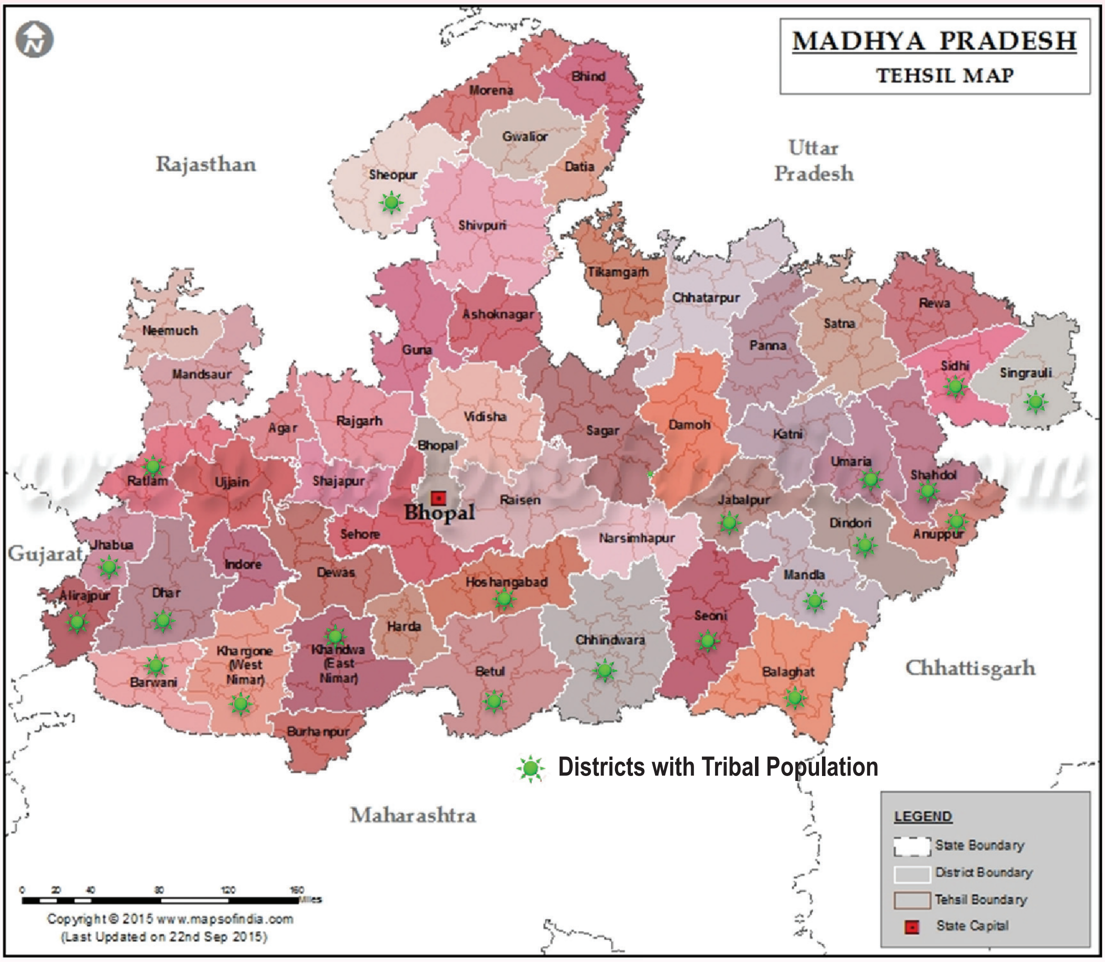

Figure 1 Distribution of tribal population in Madhya Pradesh

Tribal people residing inside the forest generally do not have any rights over the forest land they occupied in the state. But, Baiga tribe reside in an area popularly known as Baiga Chak of Dindori district attained the community rights to use the forest land they occupied for dwelling as well as to do other livelihoods activities in the year 2015. Accordingly, they became first tribal community of India to get the habitat rights from the Government under the Scheduled Tribes and Other Traditional Forest Dwellers

(Recognition of Forest Right) Act, 2006 (generally known as Forest Rights Act/FRA).

The tribal population of the state is mostly inhabited in the Indore, Jabalpur and Shahdol divisions as fifteen out of twenty one tribal districts belong to the three divisions. These tribal districts differ widely in the forest type (Figure 2 interpreted with figure 1). For example, Indore division mostly has 'open forest' where the canopy density of tree cover ranges between to 10-40 percent whereas Jabalpur and Shahdol divisions mostly have 'moderately dense forest' where the canopy density is between 40-70 percent[2]. Hence, diversity exists in the rainfall pattern, ground water availability, soil characteristics, cropping pattern, and use of agricultural chemicals among the tribal districts (Table 1).

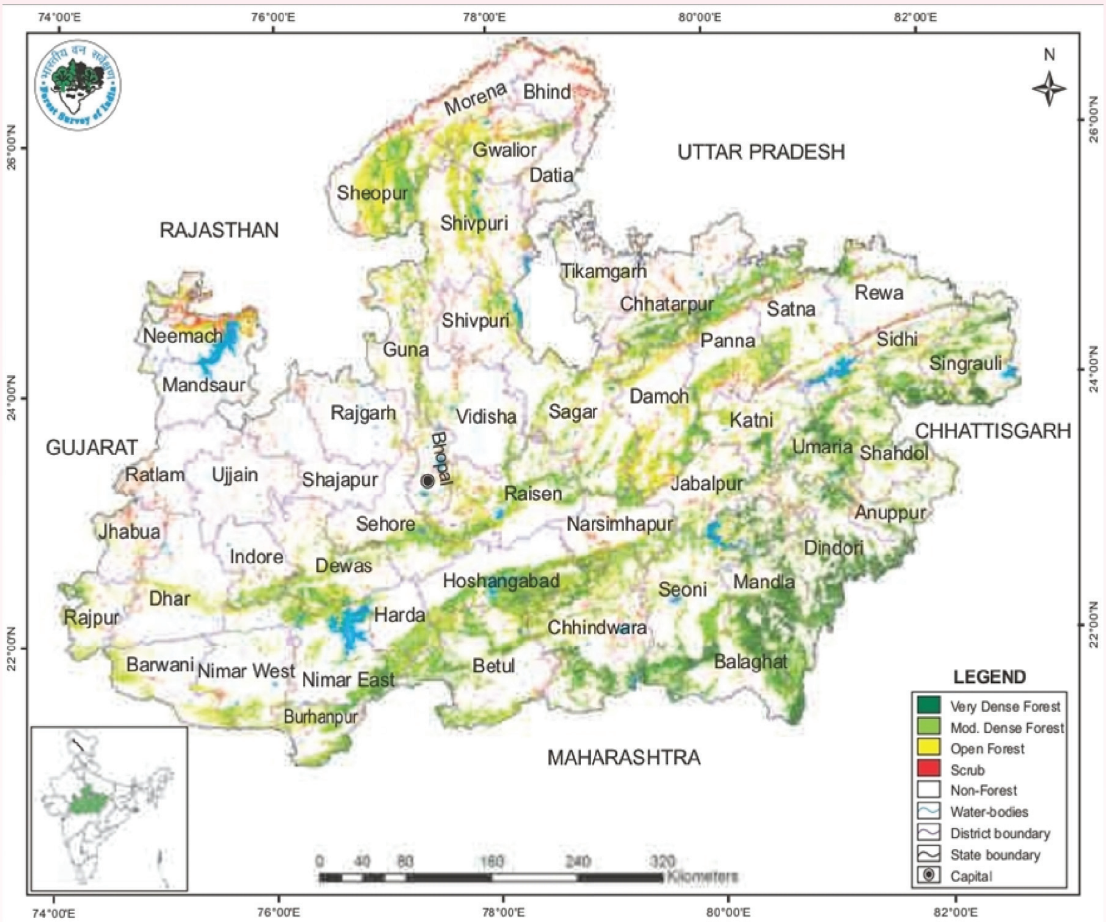

Figure 2 Forest Cover Map of Madhya Pradesh (Source: FSI, 2019)

Table 1 General Characteristics of Tribal Districts under Indore, Jabalpur and Shahdol Divisions of M. P.

Tribal Districts	Proportion of ST in population (%)	GA (000ha)	Rainfall (mm) & Rain days	Forest Cover		Soil Type	Net GWA (MCM)	NSA (000ha)	DCA as % of NSA	Major Crops Grown	Average NPK Use (kg/ha)
				Area (000ha)	Type (%)						
INDORE DIVISION											
Jhabua	87.0	360.0	774.7 37	22.2 (6.2% of GA)	VDF: 0.0 MDF: 14.0 OF: 86.0	Alluvium, Black, Sandy	222.31	189.0 (52.5% of GA)	25.9	Rice, Maize, Small millets, Sorghum, Soybean, Cotton, Groundnut, Wheat, Pulses (K&R)	62.78
Alirajpur	89.0	318.2	784.3 37	68.4 (21.5% of GA	VDF: 0.0 MDF: 30.9 OF: 69.1	Alluvium, Black, Sandy	182.79	172.0 (54.1% of GA)	22.1	Rice, Maize, Small millets, Sorghum, Soybean, Cotton, Groundnut, Wheat, Pulses (K)	62.00
Barwani	69.4	542.7	658.7 34	98.2 (18.1% of GA)	VDF: 0.0 MDF: 19.1 OF: 80.9	Medium Black, Alluvium	707.76	231.0 (42.6% of GA	29.0	Rice, Maize, Sorghum, Cotton, Soybean, Pulses (K&R), Groundnut, Sugarcane, Wheat	97.85
Dhar	55.9	815.3	835.9 33	65.1 (8.0% of GA)	VDF: 0.0 MDF:17.8 OF: 82.2	Medium Black	1132.18	502.0 (61.6% of GA)	62.9	Rice, Maize, Sorghum, Pulses (K&R), Soybean, Cotton, Groundnut, Wheat, Grass pea, Rapeseed & mustard	93.56
Khandwa	35.1	1077.6	790.9 39	340.2 (31.6% of GA)	VDF: 5.9 MDF: 53.7 OF: 40.4	Medium Black	1010.66	302.0 (28.2% of GA)	50.0	Rice, Maize, Small millets, Sorghum, Soybean, Cotton, Groundnut, Wheat, Pulses (K&R), Sugarcane	100.67
Khargone	39.0	802.5	714.4 39	129.8 (16.2% of GA)	VDF: 0.1 MDF: 36.4 OF: 63.6	Medium Black	1267.04	401.0 (49.9% of GA)	45.4	Rice, Maize, Sorghum, Cotton, Soybean, Pulses (K&R), Groundnut, Wheat, Sugarcane	134.46

Tribal Districts	Proportion of ST in population (%)	GA (000ha)	Rainfall (mm) & Rain days	Forest Cover		Soil Type	Net GWA (MCM)	NSA (000ha)	DCA as % of NSA	Major Crops Grown	Average NPK Use (kg/ha)
				Area (000ha)	Type (%)						
JABALPUR DIVISION											
Balaghat	22.5	922.9	1323.0 65	497.8 (53.9% of GA)	VDF: 26.7 MDF: 54 OF: 19.3	Red and Yellow	895.18	262.0 (28.4% of GA)	30.9	Rice, Maize, Small millets, Sorghum, Soybean, Grass pea , Sugarcane, Linseed, Pulses (K&R), Groundnut, Wheat , Rapeseed & mustard,	51.25
Chhindwara	36.8	1181.5	1001.3 58	453.1 (38.4% of GA)	VDF: 12.7 MDF::45 OF: 42.3	Shallow Black	1133.52	509.0 (43.1% of GA)	42.5	Rice, Maize, Small millets, Sorghum, Soybean, Linseed, Grass pea, Cotton, Groundnut, Wheat Sugarcane, Pulses (K&R), Rapeseed & mustard	51.47
Jabalpur	15.2	521.1	1111.2 63	117.0 (22.5% of GA)	VDF: 3.1 MDF: 43.9 OF: 53.0	Red and Black	668.23	271.0 (52.0% of GA)	57.9	Rice, Maize, Small millets, Sorghum, Linseed, Soybean, Groundnut, Wheat, Pulses (K&R), Sugarcane, Rapeseed & mustard	85.46
Mandla	57.9	580.0	1210.7 68	283.5 (48.9% of GA)	VDF: 26.5 MDF: 42.5 OF: 31.0	Red & Yellow, Medium Black	499.10	221.0 (38.1% of GA)	42.5	Rice, Maize, Small millets, Sorghum, Soybean, Grass pea, Sugarcane, Pulses (K&R), Wheat , Linseed, Rapeseed & mustard	17.32
Seoni	37.7	875.8	1027.0 61	308.2 (46.9% of GA)	VDF: 7.8 MDF::58.5 OF: 33.7	Red and Black	743.91	390.0 (44.5% of GA)	44.4	Rice, Maize, Small millets, Sorghum, Soybean, Pulses (K&R), Groundnut, Wheat, Sugarcane, Linseed, Grass pea, Rapeseed & mustard	25.68

Tribal Districts	Proportion of ST in population (%)	GA (000ha)	Rainfall (mm) & Rain days	Forest Cover		Soil Type	Net GWA (MCM)	NSA (000ha)	DCA as % of NSA	Major Crops Grown	Average NPK Use (kg/ha)
				Area (000ha)	Type (%)						
SHAHDOL DIVISION											
Anuppur	47.9	374.7	1099.6 48	86.9 (23.2 % of GA)	VDF: 12.5 MDF::39.7 OF: 47.7	Black, Sandy loam, Clay loam	345.49	146.0 (39.0% of GA)		Rice, Maize, Small millets, Niger, Soybean, Linseed, Pulses (K&R), sesame, Wheat , Rapeseed & Mustard	6.40
Dindori	64.7	747.0	1182.0 57	275.60 (36.9 % of GA)	VDF: 37.4 MDF::42.5 OF: 20.1	Red & Yellow, Medium Black	364.08	201.0 (26.9% of GA)	44.3	Rice, Maize, Small millets, Sorghum, Soybean, Grass pea, Linseed, Wheat, Pulses (K&R), Rapeseed & mustard,	3.01
Shahdol	44.7	620.5	989.5 57	197.1 (31.8 % of GA)	VDF: 6.2 MDF::41.6 OF: 52.2	Sandy loam, Clay loam	527.28	166 (27.8% of GA)		Rice, Maize, Small millets, Sorghum, Soybean, Linseed, Grass pea, sesame, Wheat, Pulses (K&R), Rapeseed & Mustard	19.55
Umaria	46.6	454.8	1075.0 51	202.3 (49.6 % of GA)	VDF: 18.7 MDF::54.2 OF: 27.1	Laterite, Sandy loam, Clay loam	448.11	160.4 (35.3% of GA)		Rice, Maize, Small millets, Sorghum, Niger, Soybean, Linseed, Pulses (K&R), sesame, Wheat , Rapeseed & Mustard	15.89

ST-Scheduled Tribes; GA-Geographical Area; GWA-Ground Water Availability MCM-Million Cubic Meter; VDF-Very Dense Forest; MDF-Moderately Dense Forest; OF-Open Forest; NSA-Net Sown Area, DCA-Double Cropped Area; K- Kharif; R- Rabi

Agriculture in the Tribal Belts of Madhya Pradesh

Agriculture in the tribal areas of Madhya Pradesh is mainly rainfed. Though the forest agro-eco systems are generally blessed with rich biodiversity and good amount of rainfall performance of tribal agriculture used to be poor in providing a good livelihood to them[3]. Generally tribal farmers practice mixed cropping systems where cereals, millets and legumes are grown together in a single plot mainly to meet the nutritional requirement of the family. The *Utera* system practiced in Hoshangabad area and Bewar system practiced in the Dindori and Balaghat districts are the best examples of the mixed cropping model of tribal farmers. However, in the course of time most of the mix cropped tribal farmlands have been shifted to other remunerative systems like rice-fallow, rice-wheat, soybean-wheat, maize-wheat systems etc. Though the tribal agro-ecosystems situated inside dense forest are mostly organic-by default those inside open forest areas are mostly conventional farmland.

The *Bewar* System

Bewar system represent traditional slash and burn cultivation technique practiced inside forest by indigenous tribal communities where they grow crops in a piece of land continuously only for three years. Then, the land is kept as fallow for a period of 6-9 years for natural rejuvenation of the forest, and they shift the cultivation to another location. Though this shifting cultivation is banned in the state under the Indian Forest Act 1927 it is still practiced in many tribal villages especially that of Dindori and Balaghat districts where Baiga tribes are predominant.

In Bewar cultivation, a mixture of 10-15 types of seeds are sprinkled over a layer of ash generated after burning the cut shrubs and tree branches in a sloppy forest land, one week before rain. In this high crop density system farmers generally cultivate crops like maize, legumes and millets such as sorghum, pearl millet, finger millet, little millet, barnyard millet, foxtail millet etc.

Bewar system is believed to be more resilient to environmental stress and gives an assured yield to farmers in low as well as excess rainfall condition. Hence, this low cost, low labour input agriculture system is the base of survival for practicing farmers as it provides them an assured crop even under changing weather condition. However, this traditional agriculture practice is considered as dangerous to the sustainability of forest ecosystem by experts as the practice enhances loss of fertile top soil in heavy rain and destruction of forest cover.

In fact, there is not much scientific research carried out on the benefits or drawbacks of the system. Hence, the fact behind farmers' claim on 'no soil erosion' and 'restoration of soil productivity after the fallow period' in Bewar system are not yet verified. Similarly, there are no data available with the extent of soil erosion in the system. Still, this shifting cultivation system was appreciated for its cooperative model agriculture by earlier researchers who worked among the tribal farmers of central India.

Soil and Water Conservation in Tribal Farmlands

Tribal farmlands located inside dense forest mostly have undulating topography and low cropping intensity. Hence, these hill slops are prone to erosion and loss of fertile topsoil with runoff water. Deterioration in soil and water quality because of natural reasons as well as agricultural production practices may not only weaken the agroecosystem but also create serious environmental problems. However, indigenous tribal farmers adopted many techniques to protect/ manage soil and water resources of their farmlands and keep the land fertile so as to ensure the best possible yield.

DOCUMENTATION OF INDIGENOUS TECHNICAL KNOWLEDGE OF TRIBAL FARMERS IN SOIL AND WATER CONSERVATION

Tribal farmers though isolated geographically, are the owners of many agriculture related Indigenous Technical Knowledge (ITK) that they have developed out of their farming experiences and farm trials. This knowledge base of tribal farmers usually preserved through oral tradition and rarely tested for scientific validation. However, proper documentation of agriculture related tribal ITKs are important as this low input agriculture system may benefit the small and marginal farmers of the country to manage their farmlands through a reduced cost of cultivation.

ICAR-Indian Institute of Soil Science carried out an exploratory study and documented the indigenous soil and water conservation techniques adopted by the tribal farmers inhabited inside the forest ecosystem of Balaghat Forest range of Madhya Pradesh during 2018-2020.

Locale of the Study

Balaghat district is located in the south-western part of Madhya Pradesh. The district shares border with Mandla, Dindori and Seoni districts of Madhya Pradesh in the North, North West and West respectively; Rajnandgaon district of Chhattisgarh state to the Eastern side; and Gondia and Bhandara districts of Maharashtra state in the South. Balaghat is one among the two districts of Madhya Pradesh where more than 50 percent of the geographical area of the district is under forest cover[1]. The district normally receives an average annual rainfall of 1323 mm mainly through the south-west monsoon from June to September with 65 rainy days annually.

Surveys were carried out in eight villages of the district to identify model farmlands where tribal farmers systematically adopted their techniques and technologies for soil and water conservation, and soil fertility management. Then, identified three villages *viz.*, Kaweli, Kulpa, and Sarra situated inside the dense forest of Paraswada and Balaghat Blocks of South Balaghat forest range (Figure 3).

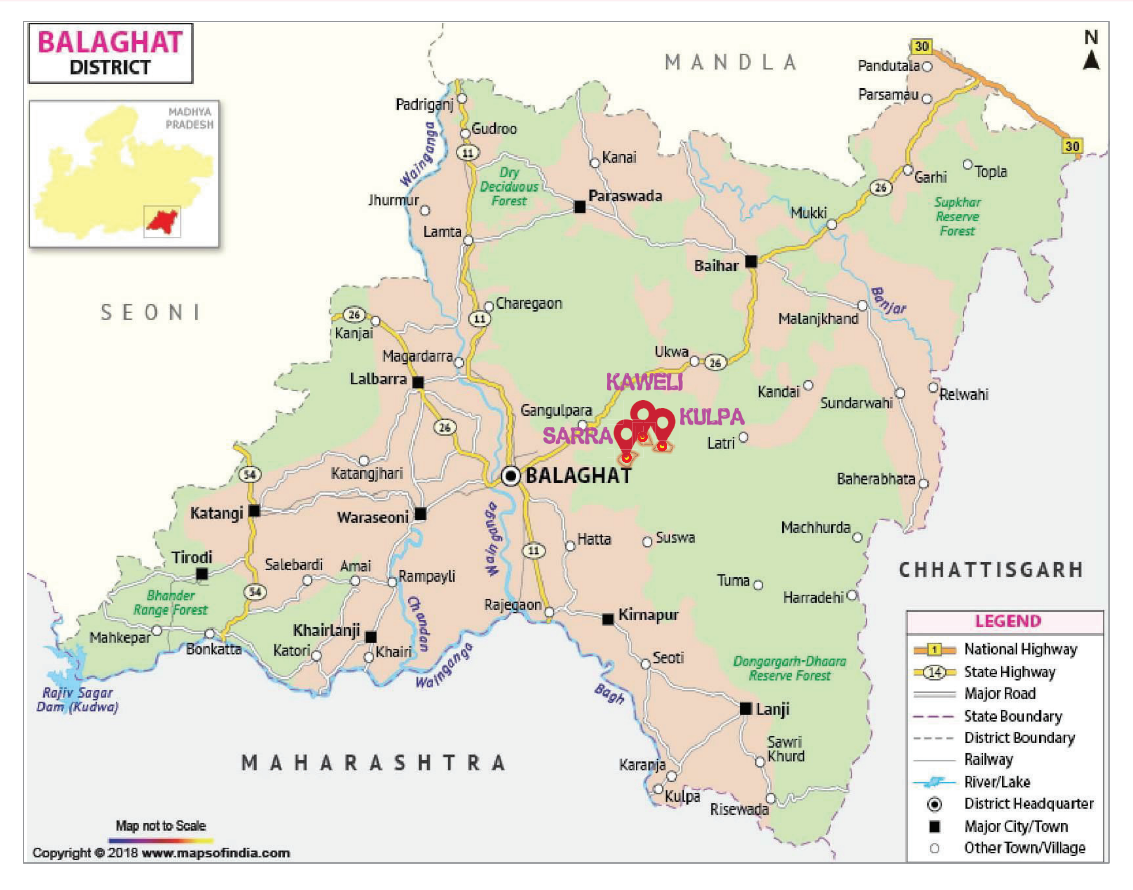

Figure 3 Location map of the study area

Kaweli, Kulpa and Sarra villages are located at a distance of 29, 32 and 40 km, respectively from Balaghat district head quarter and 10-15 km inside the forest where public or private transportation services are not available. This restricts the movement of villagers outside their locality. The population of the three villages generally comprises of Gond tribe but, nearly half population of the forest village Sarra is Baiga tribe. The geographical coordinates and general information of the three villages are given in table 2. Information on indigenous soil and water management practices and soil fertility management practices were collected through personal interview and group discussion with a random sample of 30 farmers from each of the three villages that constituted a sample size of 90. Observations on indigenous agricultural practices were made through farm field visits in the villages during the period 2018-2019.

Table 2 General Information about the three villages

Particulars	Kaweli	Kulpa	Sarra
Tehsil	Paraswada	Paraswada	Balaghat
Gram Panchayath	Kaweli	Mohanpur	Ratta
Geographical Area (ha)	253	127.41	110.8
GPS coordinates	21°51'8.3" N 80°22'47" E Altitude 590 m	21°84'85" N 80°39'79" E Altitude 624 m	21°49'40" N 80°21'47" E Altitude 680 m
Population (no.)	637 (M-322, F-315)	529 (M-247, F-282)	126 (M- 65, F- 61)
Children (0-6 years)	90 (M-51, F-39)	75 (M-36, F-39)	23 (M- 16, F- 7)
Scheduled Tribe	570 (M-286, F-284)	524 (M-245, F-279)	126 (M-65, F-61)
Literacy rate (%)	68.74 (M-80.8, F-56.9)	61.23 (M-70.6, F-53.1)	42.72 (M-40.8, F-44.4)
Households (no.)	144	113	33
Total Workers (no.)	274 (Mw -38, MGw-236)	261 (Mw-93, MGw-168)	76 (Mw -4, MGw-72)

* M-male; F-female; Mw-main workers; MGw-marginal workers

RESULTS

I. Crops and Cropping Pattern

Balaghat district is famous for rice cultivation. Around 99 percent of the Net Sown Area (NSA) of the district is under rice based cropping systems like rice-rice, rice+chick-pea-rice, rice-pulses, rice-fallow etc. Farmers of the three villages are primarily engaged with farming in the forest land demarcated for agriculture by the forest department. Most of them belong to small and marginal category and their 6-7 member families depend upon small pieces of lands for their daily food and livelihood requirements. Rice is grown as rainfed crop. Rice-fallow is the dominant cropping system (Figure 4). Some farmers grow short duration pulses and oilseed crops utilizing the residual soil moisture after the harvest of rice crop.

Figure 4 View of rice field kept as fallow after the harvest of kharif rice

Tribal farmers of the forest village Sarra were practicing shifting cultivation earlier and started settled agriculture just 50 years ago. As the village and farmlands are located in a relatively small area individual farmlands are also small in size (1-3 acres). They cultivate rice followed by a little bit of other crops like pulses, mustard, and horse gram for the family food requirement. To earn money for their other family needs they collect and sell minor forest products and work as daily labourers for the forest department. However, tribal farmers of the other two villages were shifted to settled agriculture before 100 years and their farmlands are relatively larger (5-6 acres). These tribal farmers practice commercial agriculture and sell the surplus rice (after meeting the family food requirement) through cooperatives to meet the financial requirement of the family. In general, yield of rice crop from tribal farmlands is in the range of 2.5-3.5 tonnes per hectare

Rice is grown as transplanted crop in tribal farmlands. Seedling nurseries are prepared by ploughing the land three times and seeds are broadcasted in the month of June with the onset of south-west monsoon. Transplanting of seedlings is carried out by mid July when the water level in the main fields reach sufficient level with rain water. If the south west monsoon gets delayed farmers transplant the seedlings in first week of August. Tribal farmers have adopted random transplanting (planting of seedlings without a specific spacing) of single seedlings. The spacing between plants and between rows is kept in the range of 15-20 cm. The main intercultural operation for the standing rice crop is weeding. Harvesting of the crop is done in the month of November.

In connection with various government programmes, farmers of Kaweli and Kulpa villages use hybrid seeds, chemical fertilizers and tractor drawn tillage practices in their farmlands. However, use of chemical fertilizers is lately discontinued completely due its unavailability in the nearby markets. Very few farmers whose farmlands are near roads and the land is more or less levelled were found using hired tractor drawn tillage machines for summer ploughing of fields. In general, these low input agriculture systems are completely dependent on indigenous practices and locally available inputs

II. Indigenous Cultivation Techniques in Homestead Gardens

Nutrition Garden/Kitchen Garden

The tribal villages follow a dispersed settlement pattern where households are separated from one another by few meters with no common centre for the settlement. Tribal households have maintained homestead gardens in front of the home or at the backyard where they grow crops like maize, millets, roots and tubers, ginger, turmeric and seasonal vegetables for family consumption (Figure 5 & 6).

Figure 5 View of a homestead garden maintained by tribal families

Figure 6 View of cultivation of seasonal vegetables in tribal home garden

Growing Crops on Raised Earthen Beds

Tribal farmers own a unique technique of growing crops like ginger, turmeric and taro (*Colocasia esculenta*) on earthen beds during rainy season in home gardens (Figure 7). After receiving the pre monsoon showers farmers make raised beds of 20-25 centimeter height and that much of width with a bed to bed spacing of 40-50 centimeter in front of their home or backyard. Seeds (rhizomes and corms) are sown on these earthen beds at a spacing of around 30-40 centimeters and covered with rice straw to conserve soil moisture as well as to prevent washing out of soil from the beds during heavy rain. Manuring of seed beds is done by pouring cow dung slurry or placing fresh cow dung above the rice straw mulch. It is reported that this kind of manuring enhances microbial activity along with providing nutrients to the growing plants[4]. Moreover, mulching of seed beds maintain ideal soil moisture and temperature required for seed germination, controls weeds on beds, and boost the yield[5,6,7]. Germination of seeds requires 5-8 weeks. In this technique, crops on the earthen beds would not get affected with heavy rain as channels between beds carry excess rain water to other areas. Farmers also grow marigold (*Tagetes erecta*) plants along the border to control soil born pests (Figure 8). Marigold is known for its ability to suppress nearly 14 genera of nematode pests through allelopathic effect[8, 9].

Figure 7 Growing roots and tuber crops on mud bunds

Figure 8 Growing of Marigold plants as trap crop near mud bunds

III. Soil and Water Management Techniques in Farm Fields

Terracing of Undulated Land for Farming and Fragmentation of Farm Fields into Small Units

Tribal farmlands are mostly undulated in topography. To cultivate rice farmers constructed graduated terrace steps across the hill slopes (Figure 9). The terraces are of ridged type to hold water in the rice fields. These ridges are constructed in the form of mud bunds of approximately 30 centimeters height and 30-40 centimeters width, along the edges of each terrace step. These ridges not only prevent runoff water flow to downhill area but also help to stop loss of top soil from the fields. The ridged terraces are constructed with water outflow mechanism in the form of controllable openings made in mud bunds (Figures 10 & 11).

Ridged terraces help to maintain water level in the rice fields. When the fields are flooded with more rain water, the excess water from the top fields is drained to bottom fields in a controlled manner, and finally to water resources located at downhill areas. In moderately slopped areas, height of terraces ranges between 40 to 50 cm and between 50 to 100 cm in steep slopped areas. Each terraced field is further divided into small fields of 20-30 square meter area using mud bunds of about 25 cm height and 30 cm width.

Figure 9 Land terracing and field fragmentation

Figure 10 Water outflow mechanism in the field bund

Figure 11 Controlled opening in the bund for water outflow from the field

Terraced fields hold runoff water from uphill areas and allow the sediments enriched with degraded forest litter and other organic matter carried by the runoff water to settle in the rice fields. In fact, terraced paddy fields have the potential to retain more clay, silt, and organic matter in the soil under flooded condition[10]. In this system each terrace functions as a smaller hydrographic unit and water retained by field terraces enrich the water resources of the locality[11]. In this way the farmers ensure soil fertility in their low input tribal agriculture systems. Though the system is labour intensive farmers manage it using family labour.

Grassy Field Bunds

Function of ridges and field bunds of terraced rice fields is not only restricted to water management in rice fields but also used as a walkway between small rice fields for doing various intercultural operations. However, as soils of these fields are mix of black and red with high clay content these earthen bunds are prone to damage by soil expansion during rainy season and developing cracks during summer months. This demands rebuilding of field bunds every year before the crop season. To avoid rebuilding of field bunds every year framers allow grasses to grow in these mud bunds. The shallow fibrous root systems of grasses add stability to the earthen bunds through binding the loose soil particles together and also make them durable (Figure 12 & 13).

Figure 12 Grassy field bunds during the crop season

Figure 13 Grassy field bunds during the fallow period

Grasses are permanent features of the field bunds that limit the bund maintenance to the minimum level and also provide feed material to their cattle during rainy season. After all, field bunds covered with vegetation identified as a habitat of several beneficial insects, predators, and natural enemies of rice pests[12].

Deep Summer Ploughing using Wooden Plough

Farmers harvest the rice crop manually using the family labour and leave the crop stubble as such during the fallow period. They don't practice field burning to clear the crop stubbles but, stubbles are incorporated into the soil during deep summer ploughing of the fields in hot summer months of May-June (Figure 14) using wooden country ploughs (Figure 15).

Figure 14 View of a field ploughed using wooden country plough

Figure 15 Locally made animal driven wooden country plough

They plough the fields two more times; just before the rainfall and another one after receiving the first rain to make the fields ready to absorb more rain water. Hence, fields get ploughed at least 3 times before transplanting of rice seedlings to the main fields. Third ploughing pulverises the soil thoroughly incorporating the weeds emerged after the rain into the soil, and makes the field ready for the establishment of rice seedlings. Studies on long term effects of deep ploughing showed that it improves soil physical properties and enhances infiltration of more rain water into soil, controlled pests and diseases, and also enhances root growth and crop yield[13,14,15]. In fact, the small sized fields located in between an undulated landscape, availability of family labour, and low cost involved were identified as the major factors motivating tribal framers of the villages to continue with this traditional technology though a few innovative farmers of the locality have started to avail the custom hiring of tractors for tillage operations.

Water Harvesting Ponds in Lower Hill Slopes

Natural as well as constructed water harvesting ponds in low lying areas were identified as the prime water conservation method of the tribal people of the study area (Figure 16 & 17). These water harvesting structures were designed in such a way that all the natural waterways and field channels take excess rainwater and runoff water to these low lying water resources. As agriculture is rainfed in this tribal settlement water from these resources are not generally utilized for agriculture. Hence, other than recharging of aquifers these water bodies act as a source of drinking water for animals and also for growing fishes required for family consumption. To protect the sides of the pond from falling down as well as to reduce water loss from these ponds through seepage, sides of the ponds are strengthened using locally available stones. This also helps to keep the water clean and clear once the sediments of the runoff water settle down. Though these tribal areas are resourceful for taking additional crops lack of pumping facilities to lift the water to farm fields located in high altitude restrain tribal farmers from utilizing them for agriculture.

Figure 16 Water harvesting ponds to collect runoff water from forest

Figure 17 Water harvesting ponds to collect runoff water from fields

IV. Soil Fertility Enhancement Techniques of Farm Fields

Allowing Cattle Grazing in Farm Fields during the Fallow Period

Domestication of farm animals like ox, cow and goat is a usual practice in the studied tribal villages. Each family owns at least 15-20 animals along with one or two pairs of backyard poultry. Some tribal families possess a herd of 40-50 cows and goats. In those families, two or three family members work as herdsmen and roam in the forest everyday with animals and feed them (Figure 18).

Figure 18 Herd of cattle shifting from one filed to another field inside forest

Pinning of cattle is not practiced in these villages but after harvest of the rice crop these herdsmen are allowed to keep their cows in the harvested fields during day time for grazing (Figure 19). The herdsmen keep their herd in a particular area only for one or two days depending upon the availability of feed and water for their cattle. As herdsmen never tie animals they wander throughout the fields during the entire day consuming the remnants of the rice straw and weeds grown in the fields. During this process, animals manure the fields in the form of cow dung and cow urine that gets incorporated into the soil during the deep summer plough. Interestingly, grazing of rice fields in winter is reported to have other environmental benefits like reducing the leaching of nitrogen from the fields in the early spring season[16].

Figure 19 Cattle grazing in farm fields

Manuring of Farm Fields using Farmyard Manure

Farmyard manure (FYM) is the major manure used by tribal farmers for rice crop. Though rice fields are getting manures through cattle grazing, farmers also in incorporate 1.5-2 tonnes of farmyard manure per hectare of farmland during land preparation before each crop season. There are no systematic set up for keeping cow dung or preparing manure in the cattle shelter areas. Famers keep their animals in temporary sheds made near to households during night hours (Figure 20) and animals are taken for grazing to fields or pastor lands in the morning. However, the sheds generally have no flooring and rarely covered from sides. Hence, keeping animals safely during rainy season is difficult.

Cleaning of cattle sheds requires only removal of dung and left over feed. The mixture of cow dung and leftover feed (rice straw/grasses) collected from the sheds is generally heaped in an open area near the boundary of households (Figure 21). As tribal farmers use fuelwood for cooking, cow dung use in home is restricted to plastering the walls and floor of their small houses. Hence, use of FYM in agriculture is more. Mostly the whole quantity of heaped manure is applied to rice fields as farmers use fresh cow dung for plastering and homestead gardens. Hence, quantity of FYM applied to farmlands is directly connected with the animal population of each tribal household. Generally, there is no standardization for the quality or quantity of FYM application to these farmers.

Figure 21 Farmyard manure dumping near temporary cattle sheds

Manuring of Farm Fields Using Wood Ash

In addition to farmyard manure, farmers also apply wood ash to their fields as a plant nutrient source. As these farmers use fuelwood for cooking ample amount of wood ash is generated in their kitchen every year. They spread wood ash to the fallowed field and this gets incorporated in to the soil while ploughing the field (Figure 22). Just like in the case of FYM there is no standardization of quantity and quality for wood ash application to the farm fields. Based on availability, farmers heap it either in the corner of the kitchen or near to the farm fields and spread it before field ploughing. Wood ash is a widely accepted alternate liming material in agricultural soils and a source of various plant nutrients like phosphorus, potassium, magnesium, calcium, sodium etc[17,18].

Figure 22 Wood ash application in the rice fields before ploughing

Application of Pond Soil in Farm Fields:

A few farmers of the study area use the mud/soil taken from the water harvesting ponds for improving soil fertility. The soil is dug out when the ponds dry out in summer months. As the runoff water from the uphill areas and nearby forest carry the topsoil containing remnants of dead and decayed plant and animal parts, forest litter etc the sediments in the ponds is very fertile. However, generally pond soil application to farm field is not done every year as it is a labourious process. When the depth of water harvesting ponds decrease due to sediment depositions farmers dig out mud collectively from these ponds and incorporate into fields once in 5-6 years. However, only those farmers whose farm-lands are located in low lying areas and have black soil with poor drainage apply pond mud. As pond mud contains high amount of sand and silt its application to fields would increase porosity in black soils and improves drainage.

CONCLUSION

Tribal farmers living inside the forest agro-ecosystems of south Balaghat forest range of Balaghat district manage their organic-by-default farmlands through traditional approaches and farming techniques. As these farmers rarely have access to the agricultural information sources the soil and water conservation practices and soil fertility management techniques that have been adopted in their farmlands are of indigenous origin. These farmers have been using the knowledge transferred to them through oral tradition for years. The indigenous techniques followed by the farmers are based on experiences and learning by practice. They are not only economical but also practicable under the local conditions and limited resources.

In fact, adoption of hybrid rice varieties and custom hiring of agricultural machineries by the farmers convey that they are ready to modify their farming practices if they get it near to them. There is no doubt in the fact that this trend would enhance the crop productivity of their farmland and that in turn would improve their livelihood standards. However, an inclusive agricultural development approach emphasizing protection of agricultural knowledge and techniques of tribal farmers, which also helps to integrate some changes to improve their know-how without jeopardizing their time-tested agricultural technologies that conserved their ecosystem, would be ideal for improving the agriculture based livelihoods of tribal settlements.

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Links to Sources of Data in the Table 1

- General District Information: Official Websites of Respective Districts
- Rainfall data: http://cgwb.gov.in/Regions/NCR/Reports/GW_Year_Book_2019-20_MadhyaPradesh.pdf
- Forest Cover: https://fsi.nic.in/isfr19/vol2/isfr-2019-vol-ii-madhya-pradesh.pdf
- Ground Water Availability: http://www.mpwrd.gov.in/documents/18/9ad06767-35c0-4e4f-867e-6f91a1d78500
- Net Cropped Area: http://mpkrishi.mp.gov.in/Compendium/APY3_12_05_2017.pdfAverage NPK Use & Rainy Days: http://mpkrishi.mp.gov.in/hindisite_New/AreaProduction_DifferentCrop_PartII.aspx

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